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FTC-TR-70-8

FTC-TR-70-8



**CATEGORY II PERFORMANCE  
AND FLYING QUALITIES TESTS  
OF THE HH-53C HELICOPTER  
- SUPPLEMENT -  
COLD WEATHER HOVER  
PERFORMANCE**

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**TECHNICAL REPORT No. 70-8**

**APRIL 1971**

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~~XX~~  
(20000, Wright-Patterson AFB, Ohio 45433)

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AIR FORCE SYSTEMS COMMAND  
UNITED STATES AIR FORCE**

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DEPARTMENT OF THE AIR FORCE  
HEADQUARTERS AERONAUTICAL SYSTEMS DIVISION (AFSC)  
WRIGHT-PATTERSON AIR FORCE BASE, OHIO 45433



REPLY TO  
ATTN OF

ASD/SDQH 5-10 (Maj Thompson/54921/cal/H-53/R&D 9-2)

SUBJECT

ASD Addendum to FTC-TR-70-8 Supplement H-53 Cold Performance

TO

Recipients of FTC-TR-70-8 Supplement

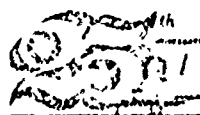
This report is a part of and should remain attached to FTC-TR-70-8 Supplement, evaluation of the H-53 "Cold Weather Hover" Performance". Paragraph numbers below correspond to the recommendations in the AFFTC Technical Report.

1. Concur. However, the data obtained in this program is presented in such a form that further data analysis is an unavoidable requirement in the process of updating the flight manual. ASD/SDQH has negotiated a commercial contract to accomplish this task. All other performance data available will be reduced concurrently, to update the entire appendix simultaneously.

2. Concur with intent. With the test data available, the range of the hover chart can be extended to minus 5,000 feet density altitude. In the data analysis process, every effort will be made to extend the hover performance prediction capability, possibly as far as minus 10,000 feet density altitude. In addition, cruise data will be extended downward to the extent feasible for operations in extreme cold.

FOR THE COMMANDER

*William D. Eastman, Jr.*  
WILLIAM D. EASTMAN, JR., Lt Col, USAF  
Chief, Helicopter Program Office  
Directorate of Combat Systems  
Deputy for Systems



FTC-TR-70-8

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(SDQH), Wright-Patterson AFB, Ohio 45433.

## FOREWORD

This report presents the results of the cold weather hover performance tests of the HH-53C helicopter, USAF serial number 68-10354. Testing was conducted between 8 January and 26 February 1971 at Eielson Air Force Base, Alaska, and Fort Greeley, Alaska in conjunction with the HH-53C cold weather tests, under the authority of AFPTC Project Directive 71-24.

The authors of this report wish to express their appreciation to Mr. Edward I. Seto for his assistance with the engineering analysis.

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## **ABSTRACT**

The cold weather hover performance tests were conducted in conjunction with the cold weather tests of the HH-53C helicopter. Interpretation of the results of this test along with previous Category II tests resulted in an adjustment to the hover performance data presented in FTC-SD-70-8. The results of this report should be used to update the Flight Manual.

## table of contents

	Page
LIST OF ILLUSTRATIONS _____	
LIST OF ABBREVIATIONS AND SYMBOLS _____	
INTRODUCTION _____	1
TEST AND EVALUATION _____	2
CONCLUSIONS AND RECOMMENDATIONS _____	15
REFERENCES _____	16



## list of illustrations

<u>Figure</u>	<u>Title</u>	<u>Page</u>
1-6	Nondimensional Hovering Performance _____	3-8
7-12	Hovering Performance _____	9-14

## list of abbreviations and symbols

<u>Item</u>	<u>Definition</u>	<u>Units</u>
A	rotor disk area	ft <sup>2</sup>
C <sub>P</sub>	power coefficient	- - -
C <sub>T</sub>	thrust coefficient	- - -
M <sub>TIP</sub>	advancing blade tip Mach number	dimensionless
R	rotor radius	ft
SHP	shaft horsepower	$\frac{550 \text{ ft-lb}}{\text{sec}}$
W	gross weight	lb
$\rho$	air density	slug per ft <sup>3</sup>
$\Omega$	rotor angular velocity	rad per sec

## INTRODUCTION

Previous HH-53C hover performance testing (FTC-TR-70-8) partially defined rotor blade compressibility and resulted in the recommendation that additional testing be conducted to more completely define this effect.

The HH-53C is a rescue-equipped, twin-engine, six-bladed, fully articulated rotor helicopter, manufactured by Sikorsky Aircraft, Division of United Aircraft Corporation, at Stratford, Connecticut. The aircraft is powered by two General Electric T64-7 engines with an uninstalled, non-flow limited, rating of 3,925 SHP at sea level standard day. Design rescue mission gross weight is 37,399 pounds with a maximum gross weight of 40,750 pounds.

## TEST AND EVALUATION

Hover performance was evaluated at wheel heights of 100, 80, 47, 22 and 10 feet. Performance tests at two different  $M_{TIP}$  values were flown at all wheel heights except 80 feet. Both tethered and free flight hovering techniques were used during testing. No testing was accomplished in winds above 2 knots.

Previous data for the HH-33C (FTC-SD-70-8, reference 1) were presented without a plot of wheel height versus  $C_p$  for lines of constant  $C_T$ . In correlating the data acquired during the cold weather tests with the previously published data (FTC-SD-70-8), it was necessary to construct a crossplot combining data from both tests.

The Flight Manual's Indicated Torque Required to Hover chart (A-7) was in error. It showed torque up to 11-percent higher than was actually required. Interpretation of the results of this test along with previous Category II tests resulted in an adjustment to the hover performance curves presented in FTC-SD-70-8, figures 1 through 4, appendix I. The data presented in this report (figures 1 through 12) should be used to update the Flight Manual. (R 1)<sup>1</sup>

Minus 6,000 feet density altitude days were a frequent occurrence during the test program and density altitudes below minus 9,000 feet were encountered. In such cases the Indicated Torque Required To Hover chart (A-7) in the Flight Manual did not have sufficient range to be used for the conditions encountered. The range of this chart should be increased to minus 10,000 feet density altitude to provide adequate range for low-altitude, cold weather operation. (R 2)

<sup>1</sup>Numbers indicated as (R 1), etc., represent the corresponding recommendation numbers as tabulated in the Conclusions and Recommendations section of this report.

HH-53G USARF SIN 68-10354

T64-GE-7 ENGINES

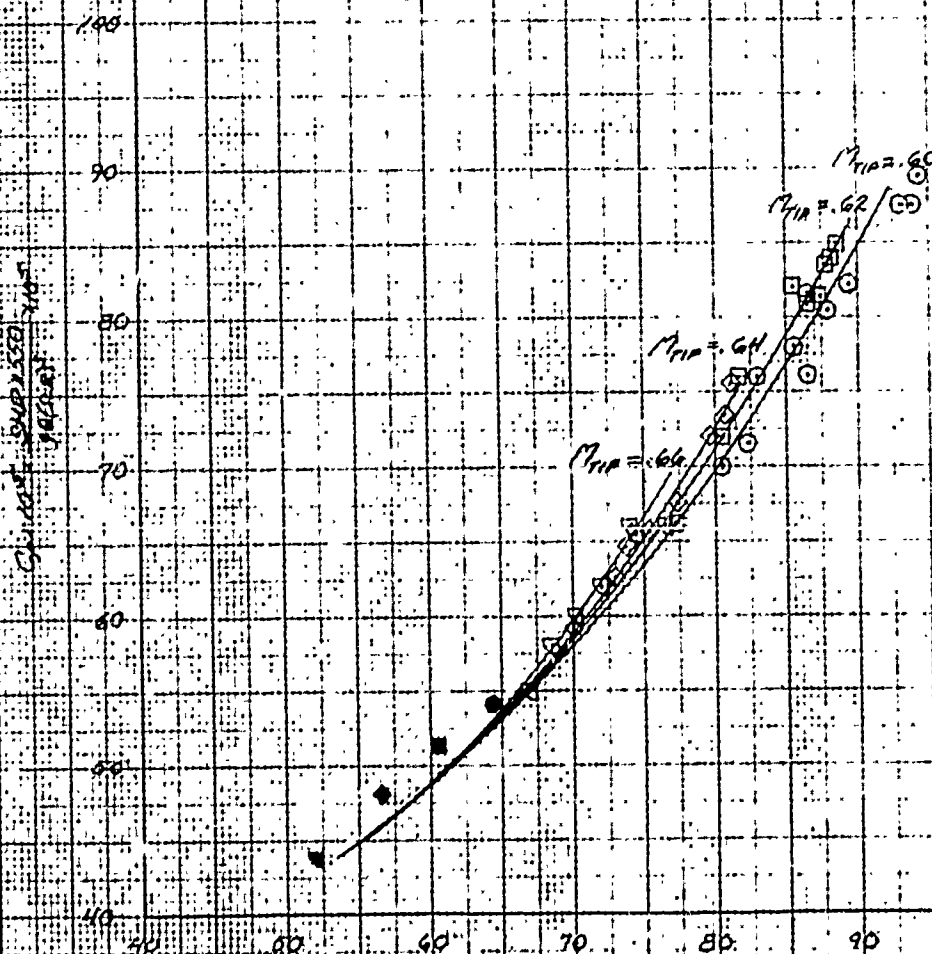
5-Feet Wheel Height

450-gallon tip tanks installed

engines not equipped with EAPB

NOTE: Solid symbols denote free flight hover

Symbol	M <sub>tip</sub>
○	.60
□	.62
◇	.64
◊	.66



$$C_p \times 10^4 = \frac{K}{\rho A (V_{tip})^2} \times 10^4$$

10-Foot Wheel Height  
450-gallon tipplanks installed  
engines not equipped with EAPS.  
Solid symbols denote free flight hover.

Symbol	Mp.
○	.60
□	.62
◇	.64
▢	.66
△	.79
⊙	.84

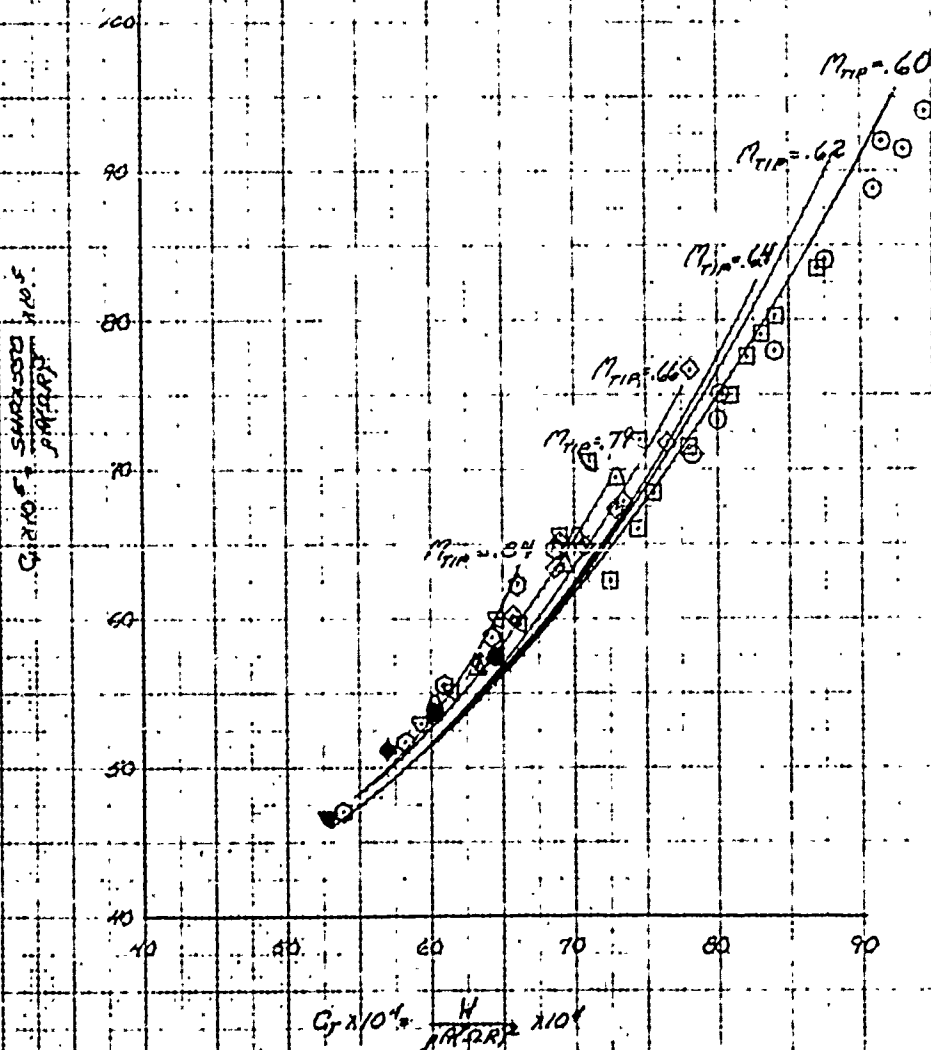


Figure 2. Nondimensional Hovering Performance

HH-53C USAF S/N 68-10354

764-GE-7 ENGINES

22-Foot Wheel Height

450-gallon tip tanks installed  
engines not equipped with ERAS

NOTE: Solid symbols denote free flight hover

Symbol	$M_{TP}$
○	.60
□	.62
◇	.64
△	.66
▽	.79
○	.84

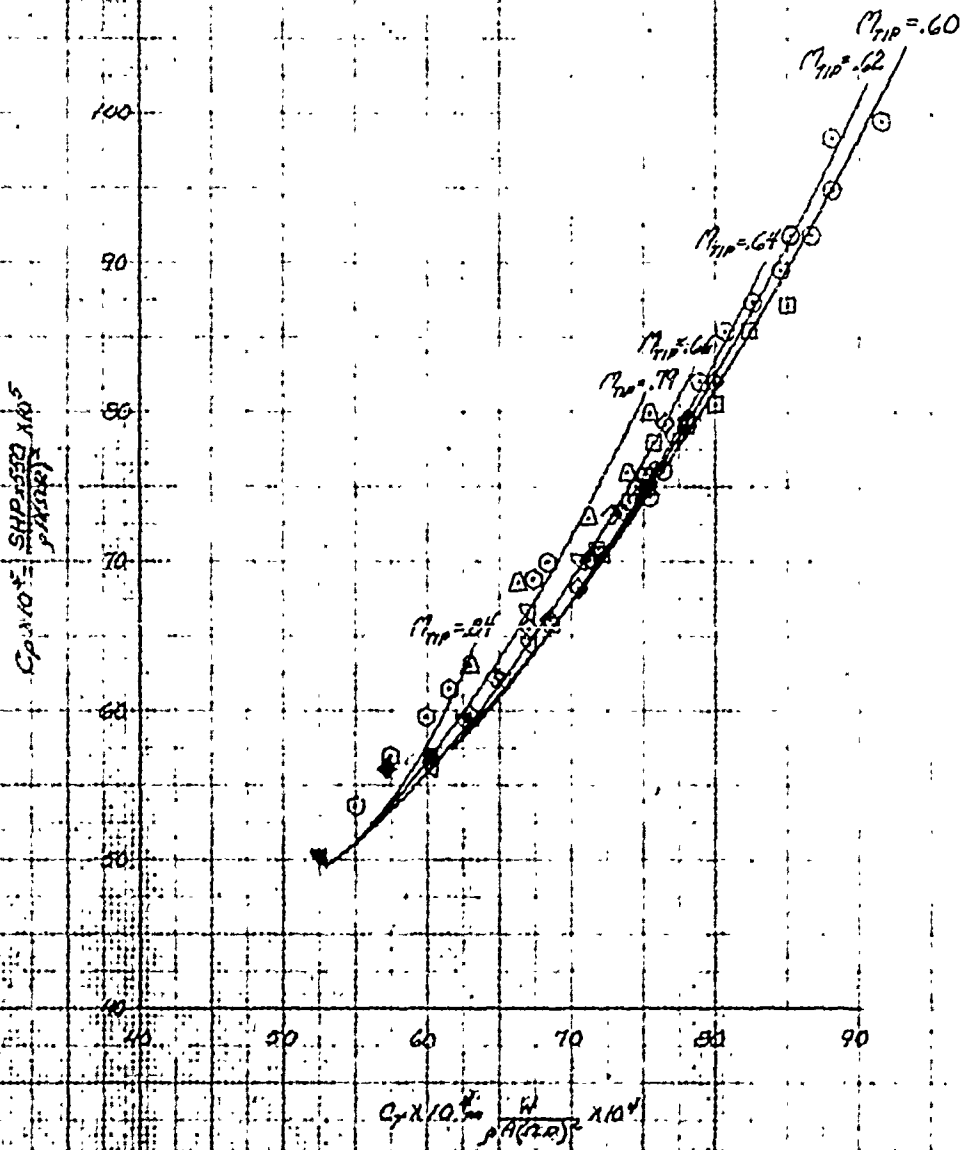


Figure 51 Nondimensional Hovering Performance

HH-53C USAF S/N 68-10534  
T64-GE-7 ENGINES

47-Foot Wheel Height  
450-gallon tip tanks installed  
engines not equipped with EAPS

NOTE: Solid symbols denote free flight hover

Symbol	$M_{TIP}$
○	.60
□	.62
◇	.64
▽	.66
△	.79
○	.84

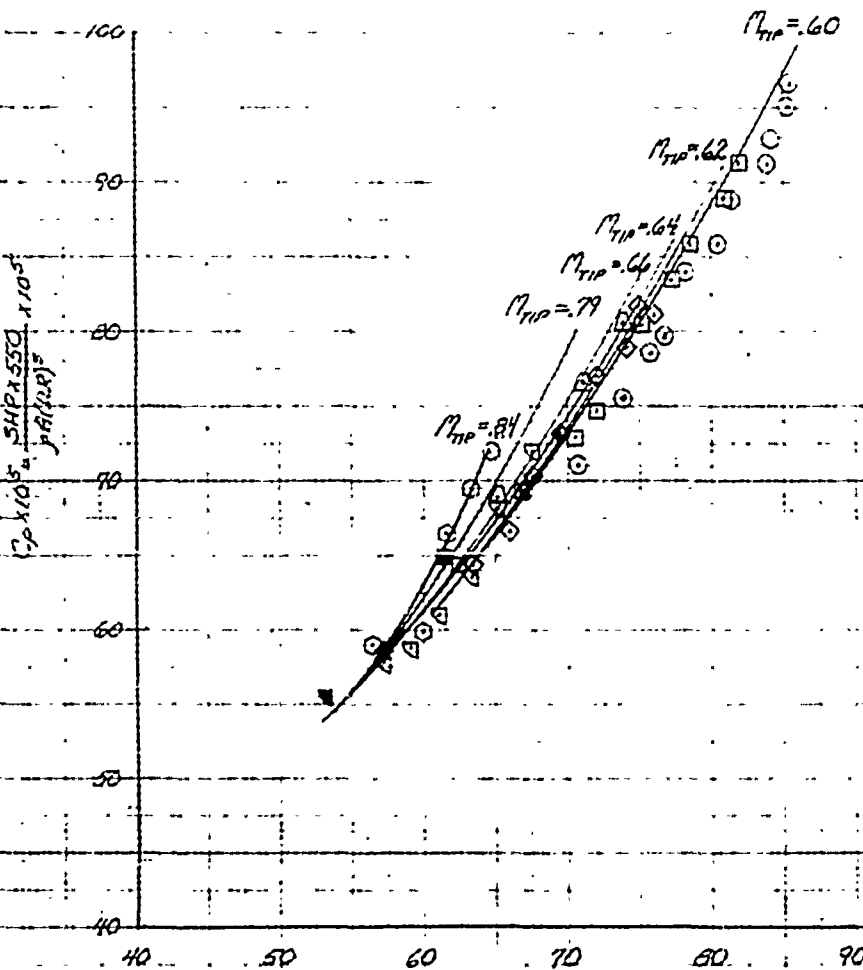


Figure 4. Nondimensional Hovering Performance



HH-53G USAF S/N 68-10354  
 T64-GE-7 ENGINES  
 80-Feet Wheel Height  
 450-gallon Fuel tanks installed  
 engines not equipped with EAPS

NOTE: Shaded symbols denote free flight hovers.

Symbol	$M_{T10}$
○	.60
◻	.62
◇	.64
◊	.66
●	.84

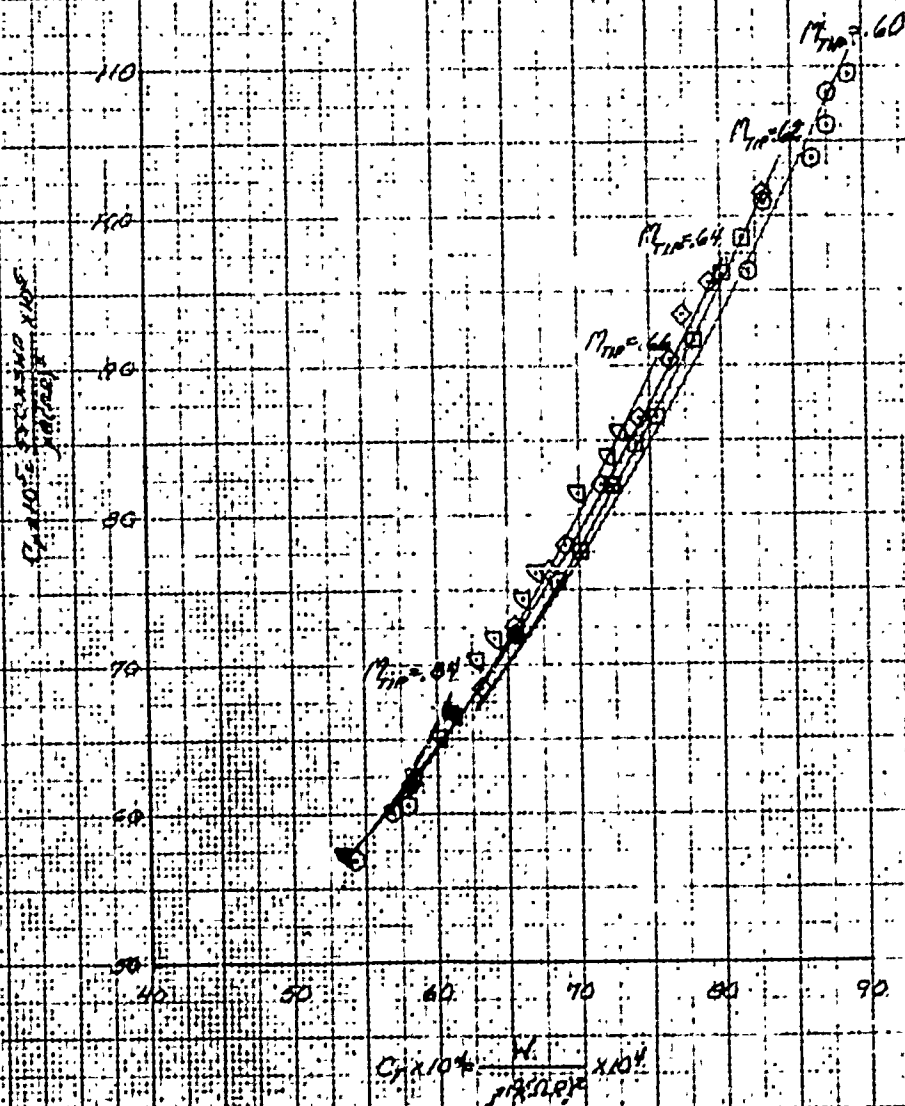


Figure 6. Nondimensional Hovering Performance

HH-33C USAF S/N 68-10354

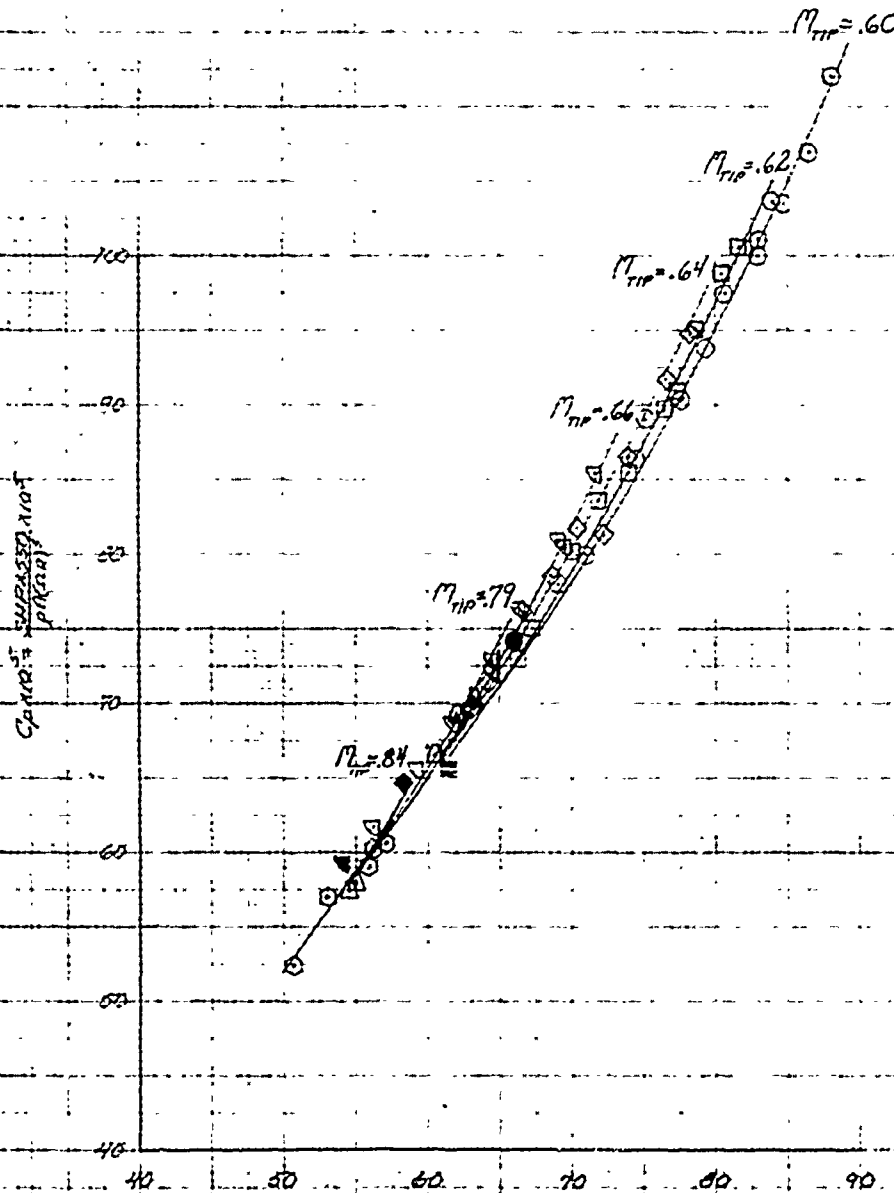
764-GE-7 ENGINES

100-Foot Wheel Height

450-gallon tip tank installed  
engines not equipped with EAPS

NOTE: Solid symbols denote free flight hover.

Symbol	$\gamma_{tip}$
○	.60
□	.62
◇	.64
△	.66
▽	.79
◇	.84



$C_{H100} = \frac{W}{\rho A V_{100}^2}$

Figure 6. Non-dimensional Hovering Performance

HH-53C USAF S/N 68-10354

764-GE-7 ENGINES

$M_{TIP} = 0.60$

NOTE: Derived from Figures 1 to 6.

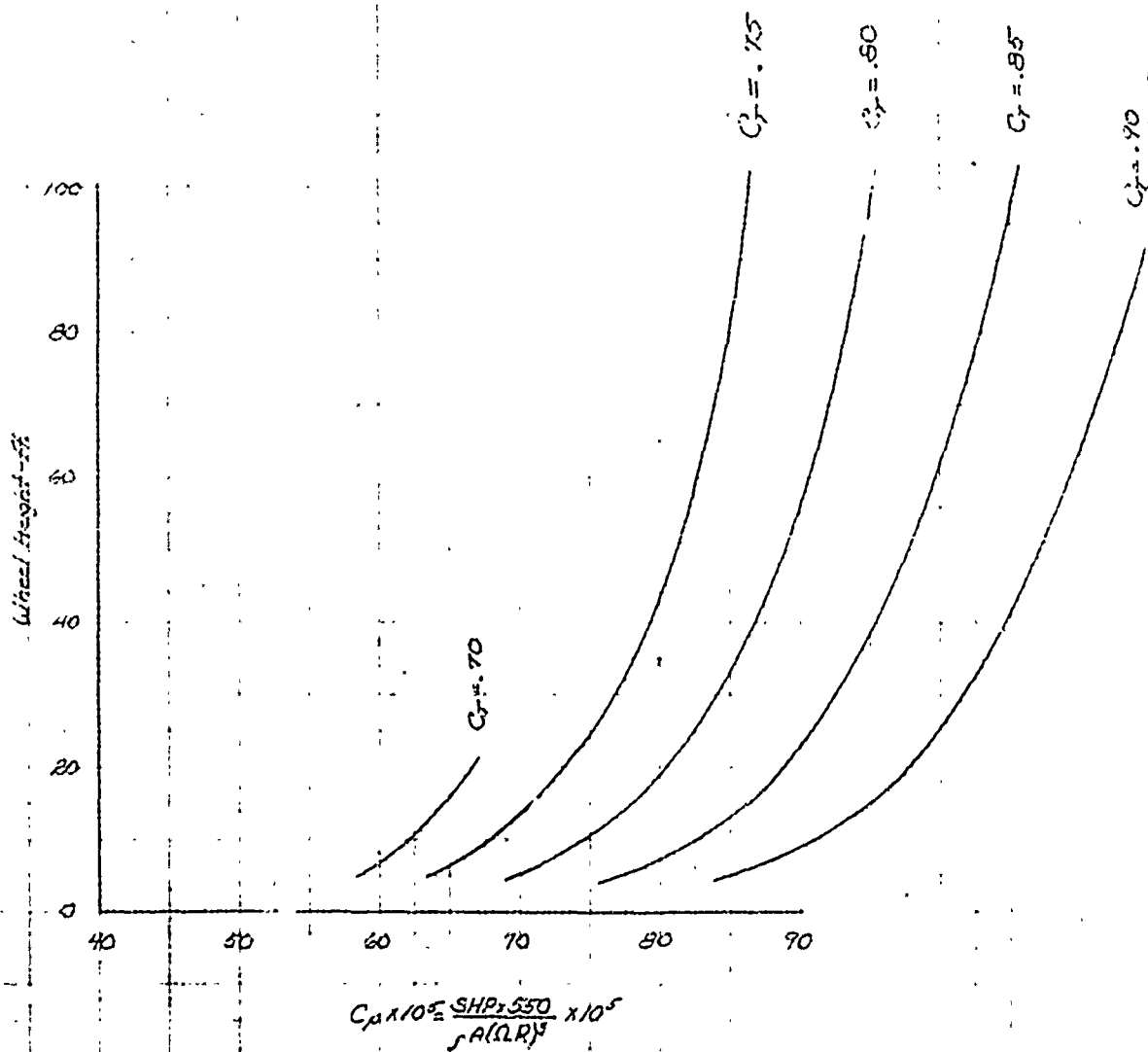


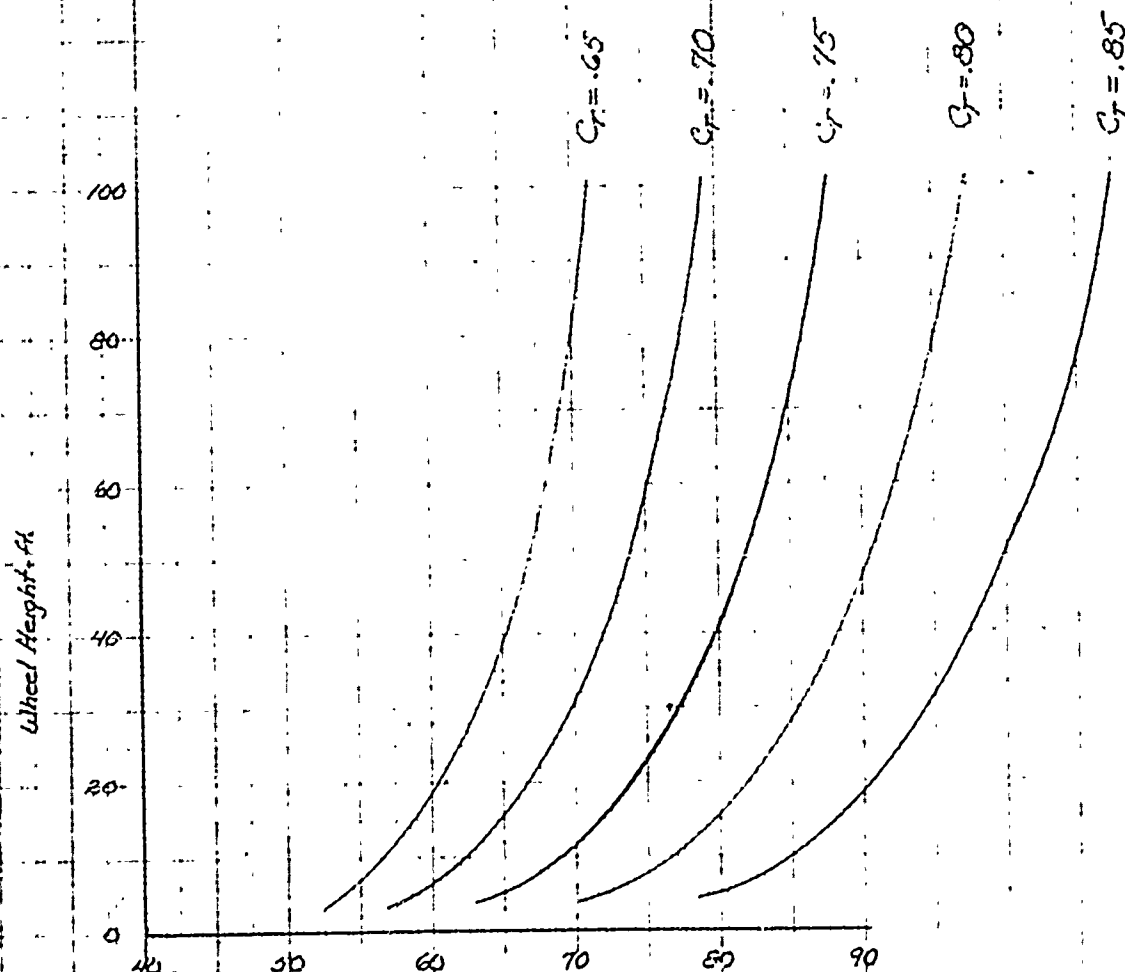
Figure 7. Hovering Performance

HH-53C USAF S/N 68-10354

764-GE-7 ENGINES

$M_{TID} = 0.62$

NOTE: Derived from figures 1 to 6.



$$C_L \times 10^5 = \frac{SHP_{550}}{\rho A (\Omega R)^3} \times 10^5$$

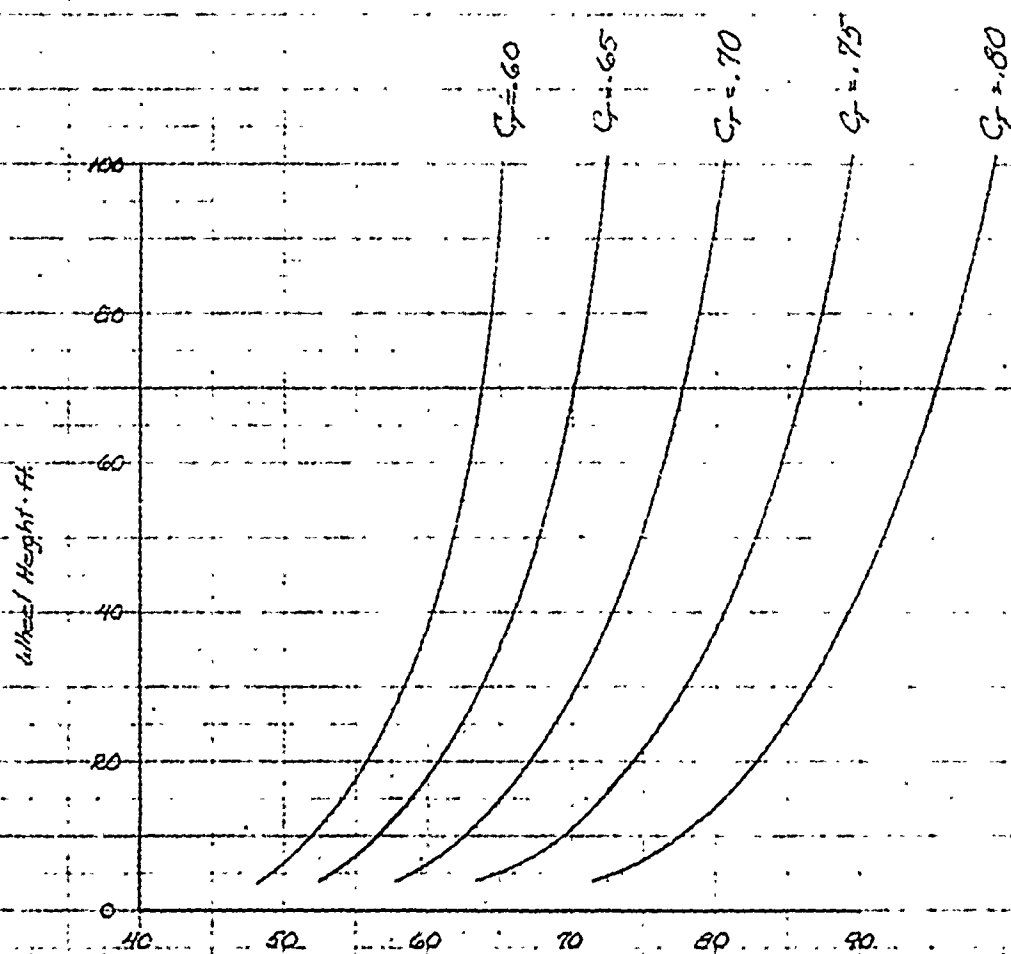
Figure 8. Hovering Performance

HH-53C USAF S/N 68-10354

T64-GE-7 ENGINES

$M_{TP} = 0.64$

NOTE: Derived from figures 1 to 6.



$C_p \times 10^5 = \frac{SHP \times 550}{P_{RTR}} \times 10^5$

Figure 9. Hovering Performance

HH-53C USAF S/N 68-10354

T64-GE-7 ENGINES

$M_{TPO} = 0.66$

NOTE: Derived from figures 1 to 6.

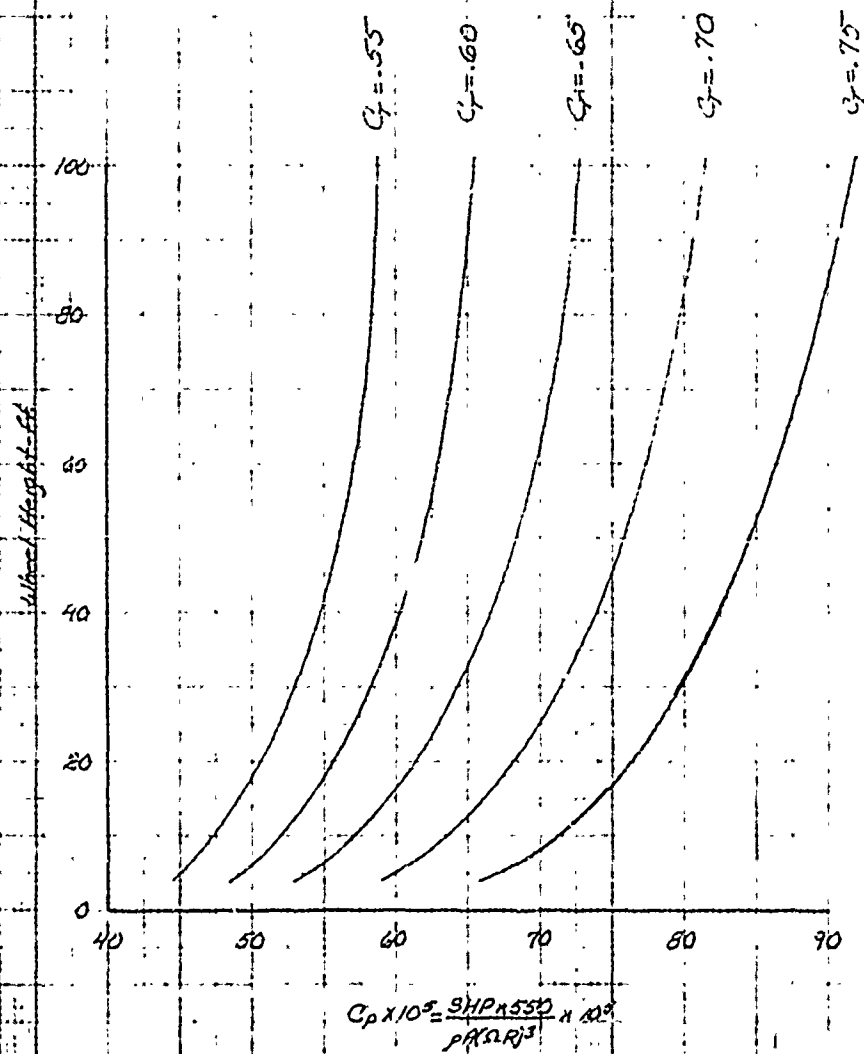


Figure 10. Hovering Performance.

HH-53C USAF S/N 68-10354  
 T64-GE-7 ENGINES  
 $M_{TIR} = 0.79$

NOTE: Derived from figure 1 to 6.

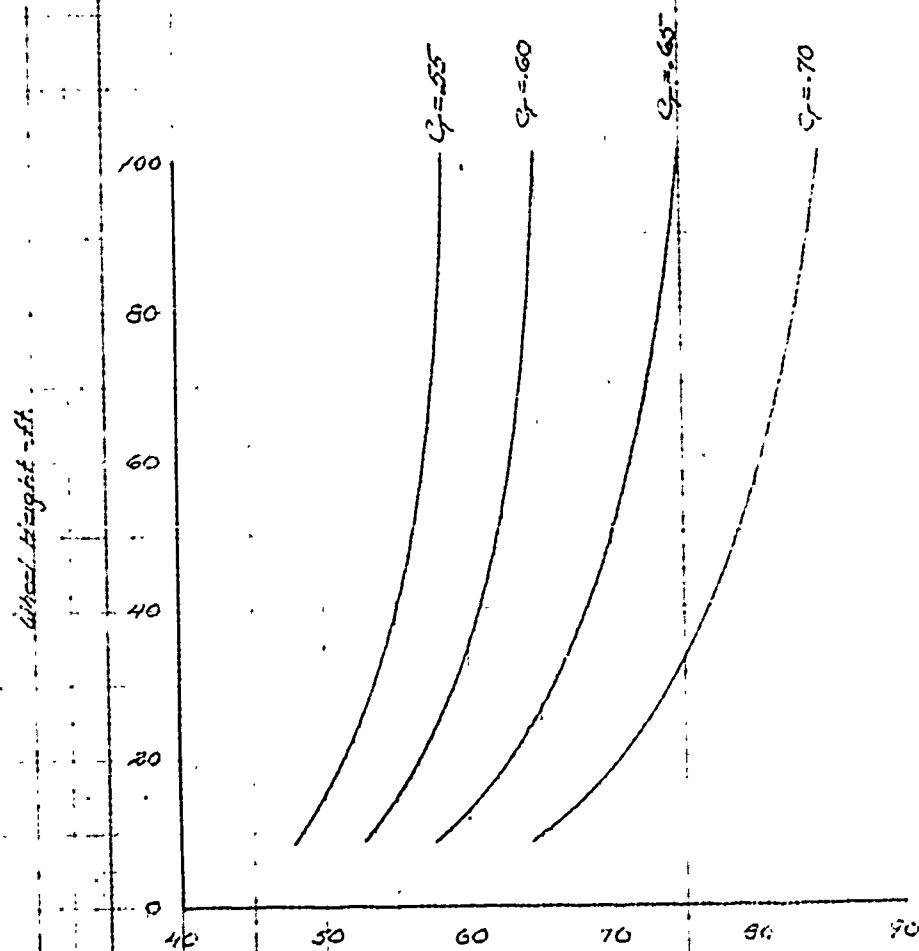


Figure 11) Hovering Performance

HH-53G USARF SIN 68-10354

T64-GE-7 ENGINES

$\eta_{prop} = 0.84$

NOTE: Derived from figures 1 to 6.

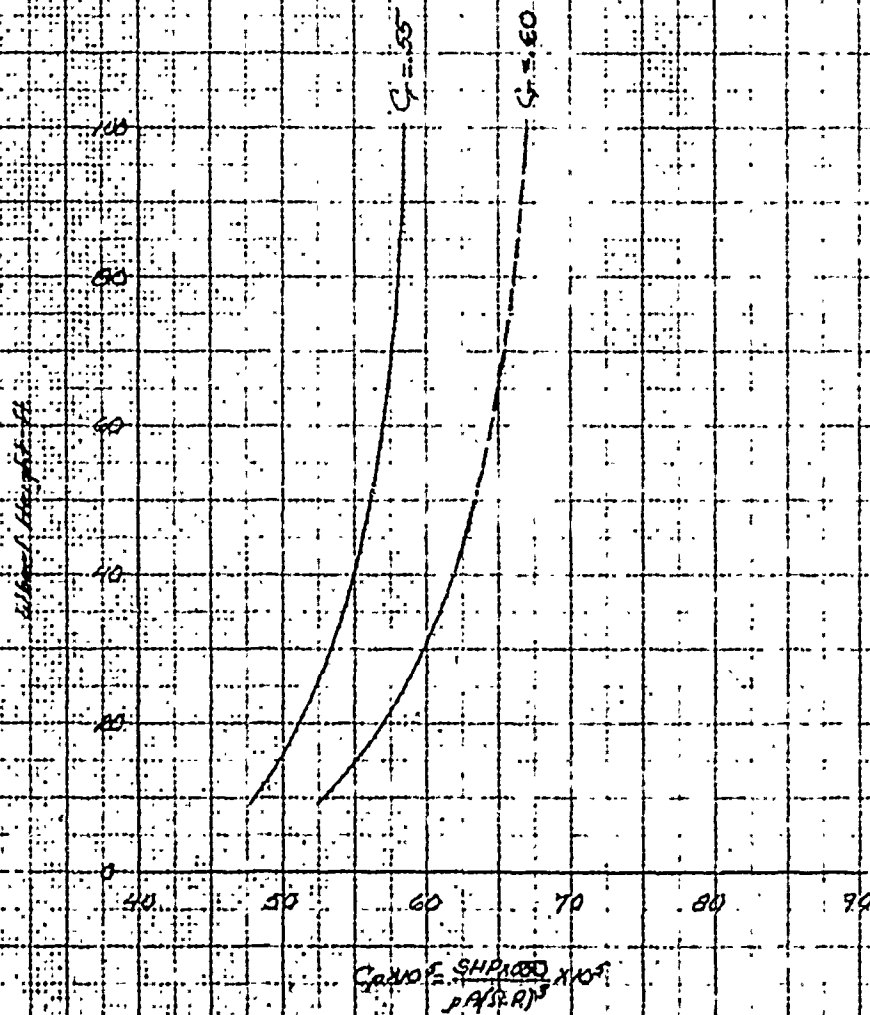


Figure 14. Hovering Performance



## **CONCLUSIONS AND RECOMMENDATIONS**

The Flight Manual's Indicated Torque Required to Hover chart (A-7) was in error. It showed torque up to 11-percent higher than was actually required. Interpretation of the results of this test along with previous Category II tests resulted in an adjustment to the hover performance curves presented in FTC-SD-70-8, appendix I, figures 1 through 6.

1. The data presented in this report should be used to update the Flight Manual (page 2 ).

The Flight Manual Indicated Torque Required to Hover chart (A-7) did not have sufficient range of density altitude to define the performance of the helicopter.

2. The range of this chart should be increased to minus 10,000 feet density altitude (page 2 ).

## REFERENCES

1. Flight Manual USAF Series HH-53B, HH-53C, and CH-53C Helicopters, T.O. 1H-53(H)B-1, 30 June 1970, Operational Supplement 31 December 1970.
2. Nasal, Timothy P., Balfe, Paul J., Major USAF, UH-1F Hover Compressibility Tests, FTC-TR-68-30, Air Force Flight Test Center, March 1969.
3. Barbini, Wayne J., et al., Category II Performance and Flying Qualities Tests of the HH-53C Helicopter, FTC-TR-70-8, Air Force Flight Test Center, April 1970.
4. Barbini, Wayne J., et al., Category II Performance and Flying Qualities Tests of the HH-53C Helicopter, FTC-SD-70-8, Air Force Flight Test Center, May 1970.

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